RELATIONSHIPS BETWEEN DEER DAMAGE TO EXPERIMENTAL APPLE ORCHARDS AND NEARBY HABITAT

AN HONORS THESIS

Presented in Partial Fulfillment of the Requirements
for the Degree Bachelor of Science

by

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1988

ABSTRACT

The relationship between damage to apple orchards by white-tailed deer and surrounding habitat was examined. Habitat analysis utilizing aerial photographs, habitat maps and ground checks was combined with deer damage and deer population indicies to determine the best model for the prediction of deer damage. The lengths of roads was found to be the variable most highly correlated with deer damage ($r=0.87$, $p=0.05$). Other variables highly correlated to deer damage or deer population indicies included the amounts of woods and cultivated land. The stepwise regression model sugested that the amounts of roads and water on a study area would explain 99.9% of the variation in deer damage. Sample size was the major problem in this study; a sample size of 135.5 was determined to be necessary for the acceptable 10% accuracy at a 0.05 confidence limit level. Future studies were deemed necessary, and solutions to the problems encountered were suggested.

INTRODUCTION

Ohio growers have experienced a rapid increase in damage to orchards by white-tailed deer (*Odocoileus virginianus*) since 1970 (Scott and Townsend 1985). The resulting economic loss has drawn increasing attention to the deer damage problem (Scott and Townsend 1985), warranting further investigation of the factors contributing to deer damage. Proximity of tree plantations to favorable deer habitat may result in a higher incidence of deer damage. A habitat evaluation in areas where the degree of damage is known may yield a model through which damage can be predicted.

Methods of habitat evaluation range from analysis of habitat types in large parks to detailed analysis on a small area for the habitat requirements of a single species (Riney 1982). A combination of large scale aerial photographs (1:1000- 1:20,000), topographic maps and ground checks can provide sufficient information to determine the potential for an area to support a species (Riney 1982).

The habitat requirements of white-tailed deer are well documented (Dasmann 1981). A quantitative measurement of the habitat components vital to white-tailed deer on study areas can produce a multivariate habitat model. This model may be used to predict not only the population supported by the habitat, but also the degree of damage expected to orchards within the area.

This study investigates the relationships between selected habitat variables and deer damage to young apple trees. A habitat analysis utilizing aerial photographs, habitat maps, and ground checks provides quantity data. When these data are analyzed statistically to include the variables of deer population and deer damage, they yield a multivariate regression model which correlates deer damage and surrounding habitat. Once these relationships are determined, a model for the prediction of deer damage can be derived.

METHODS AND MATERIALS

Study Areas

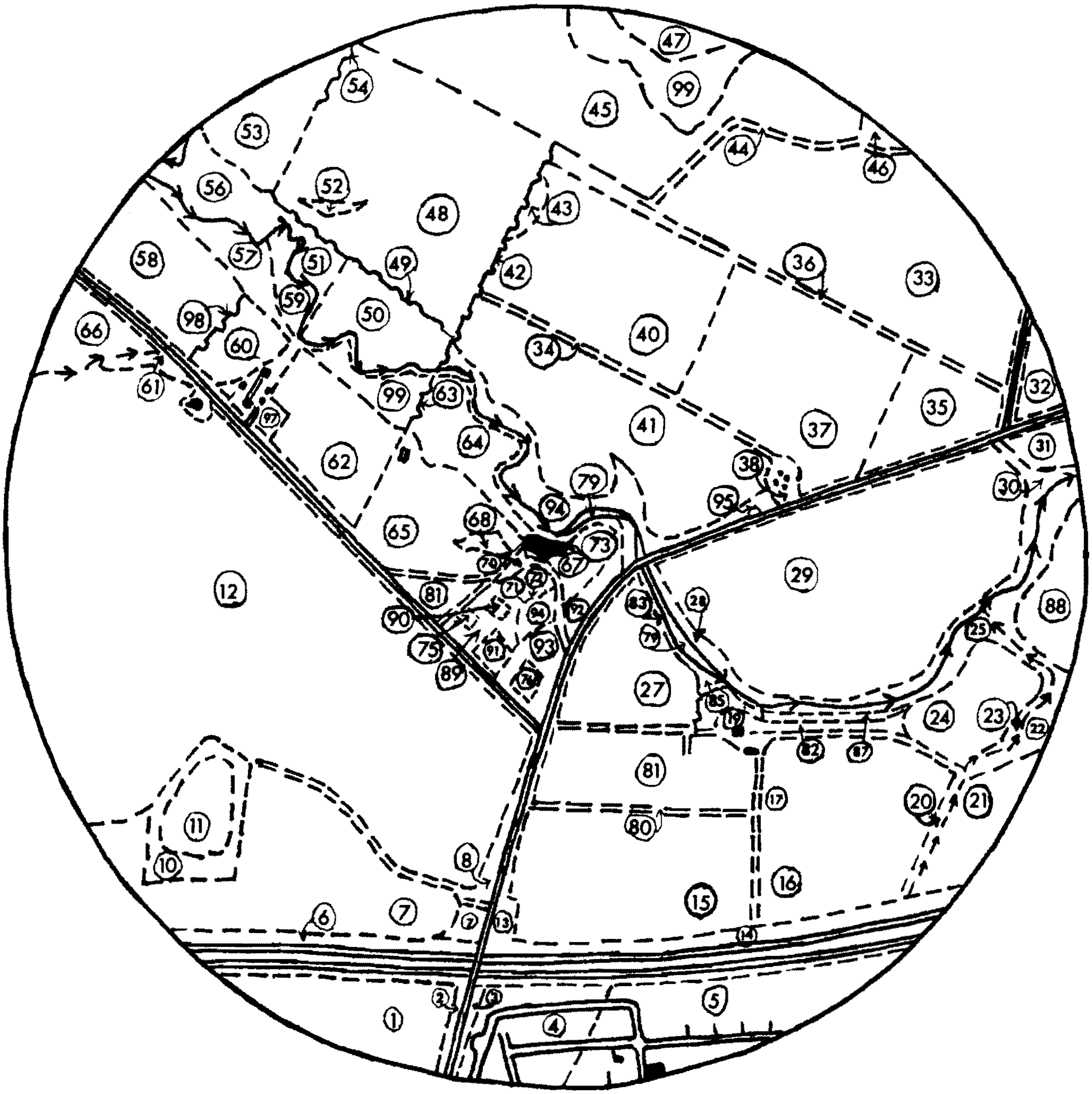
The five study areas used in my work surround apple plantations established by Kerry Mower for his Ph.D. research. The orchards are located on OARDC experimental farms throughout Ohio. Each orchard consists of 60 apple trees; 30 control trees are enclosed by 1.52 m high wire mesh fencing and 30 trees are left open to deer. Each of my study areas encompass 314.2 ha based on a 1 km radius circle measured from the center of the orchard.

Habitat Analysis

The locations of my study areas were identified on soil survey and topographic maps. Aerial photographic coverage of the study areas was obtained through the ODNR Division of Soil and Water Conservation Remote Sensing Department. Mr. James Given researched the existing photography and provided the appropriate photos. One stereo pair provided adequate coverage of each 314.2 ha site; the photographic scales ranged from 1:24,000 to 1:40,000, and the photographs were taken between 1979 and 1986.

On each photo the orchard or orchard site was identified and outlined; one kilometer was measured from the orchard center and a circle with a one km radius was drawn. Habitat maps were prepared from the photos using a zoom transfer scope. The features of each site and all surrounding land use components were transfered from the photos to the habitat maps (Figure 1). These maps served as guides for gathering field data.

Fig 1. Madison County cover map, used for gathering habitat data in the field.



Map scale = 1:11,665 [Original photo scale = 1:24,000]

①= Tract number
= Roads
= Fencerows
= Rivers & streams
= Cover type or field boundary
= Buildings
= Young apple orchard

Field sampling was begun in October 1987, and completed by November 7, 1987. At each site the entire sample area was surveyed from a car or on foot. The ODNR cover mapping technique (Gehres et al. 1984) was used to code each tract according to land usage. Tract numbers were assigned to fields, orchards, water bodies, brushlands, woodlots, fencerows and residential or industrial areas. The code corresponding to appropriate cover type was recorded on field data sheets by tract number (Appendix A). Additional codes were added to account for specific agricultural crops, orchards and non-inventory areas. In disturbed or fall plowed areas, the land owner or manager was consulted to determine previous crops or woody species that had been clear cut. Large wooded areas were surveyed from random transects. At random intervals the nearest tree was identified and the species recorded. The most appropriate code was assigned to each tract after determining the most abundant species. Field guides for weeds (Wax et al. 1981) and trees (Little 1980) were used in making identifications.

Area measurements were completed using a Jan-Del electromagnetic digitizer. The digitizer was calibrated to 314.2 ha by running the stylus around the circle boundary of each cover map. Each tract on the cover map was then traced and the computer displayed its area in hectares. This area was recorded on the field data sheets. The one km radius was used to calibrate the digitizer to obtain linear measurements for roads, streams and fencerows.

Another variable measured was edge. The edge index for each study area was determined using the radial overlay designed by Schuerholz (1974). Examples of edge considered valuable for deer include the borders of woods, fields, ponds, orchards, meadows, rivers, brushlands and clearings (Stocker and Gilbert 1977). These edges were counted, while non-valuable edge (such as that in large residential areas) was ignored.

Other indicies included in the analysis were deer population and deer damage. The ODNR Division of Wildlife was contacted for information on deer populations; Mr. Bob Stoll (Waterloo office) provided the deer population statistics for the counties in this study. The indicies utilized were total number of highway accidents where deer were actually hit per county. The other indicies available (buck gun harvest per square mile by county) were consistant with the highway accident indices, although the later offered higher variability. Kerry Mower provided August 1986 data on the deer damage for the orchards concerned. The difference between treatment and control trees in reduction of woody growth was the damage index used.

Multivariate regression analysis was performed using the OSU computer and the Statistical Analysis System (SAS 1980). Each study site was given a location code, and the following variables for each site were entered: deer population indicies; number of edge points; the linear values for roads, streams and fencerows; and the area values for non-inventory land, water, cultivated land, non-cultivated land, orchards, brushlands, and wooded areas (Tables 1 and 2). All predictor variables were plotted against the response variable (deer damage), and a stepwise regression produced a model based on the most highly correlated variables. A Pearson correlation coefficient matrix was also produced to ascertain the relationships between all variables. The confidence limit level was $p<0.05$.

Table 1. Area or linear measurement of major land use categories by county.

County (Location code)	Land use category								
	Non-Inventory (ha)	Water (ha)	Cultivated (ha)	Non Cultivated (ha)	Brushland (ha)	Woodland (ha)	Orchards (ha)	Roads (m)	Fencerows (m)
Madison (4)	12.0	2.8	197.3	69.4	28.0	7.5	1.2	8283.5	1514.8
Wood (7)	5.3	0.0	268.1	13.0	1.3	18.1	0.6	7034.6	1075.9
Clark (5)	20.8	0.1	253.3	11.1	2.2	16.0	0.3	4742.4	762.6
Fairfield (3)	9.8	1.3	64.4	59.8	117.2	62.5	109.5	3541.5	4553.8
Mahoning (8)	81.4	1.3	66.0	85.5	18.2	55.6	3.3	11426.3	392.0

Table 2. Indices for edge, deer population, and deer damage.

County (Location code)	Edge points[1]	Deer population[2]	Deer damage[3]
Madison (4)	72	98	1348.5
Wood (7)	82	116	400.5
Clark (5)	79	198	65.4
Fairfield (3)	84	286	147.5
Mahoning (8)	71	278	-154.0

[1]Determined by placing radial overlay over cover maps and counting the number of times a transect crossed edge valuable for deer (Schuerholz 1974).

[2]Total number of highway accidents where deer were actually hit per county.

[3]The difference between treatment and control trees in reduction of woody growth.

RESULTS AND DISCUSSION

The major problem encountered in this study was sample size. Several limitations were imposed, most importantly that of obtaining appropriate aerial photo coverage. Of the eight orchards established by Kerry Mower, only five were covered by existing aerial photography. Also, the expense involved in preparing habitat maps, completing field sampling, and processing the data was quite extensive, prohibiting an increase in sample size. The sample size needed to obtain 10% accuracy at a 0.05 confidence limit level is 135.5 (Snedecor 1956). In this calculation, the mean (5005.7) and the standard deviation (2733.4) of the road variable was used, as this was the variable most highly correlated with deer damage. Sample size needed was calculated to be higher for variables less strongly correlated than roads.

Only the length of roads variable was significantly correlated ($r=0.87$, $p=0.05$) with deer damage (Table 3). The positive correlation suggests that more deer damage can be expected as the amount of roads increases. The deer population index, however, was negatively correlated with length of roads ($r=-0.95$, $p=0.01$), indicating there were fewer deer as the amount of roads increased in a study area. It is difficult to ascertain any biological basis for these results. In terms of land use and deer movements, it appears that deer do not orient in any general pattern relative to highways (Feldhamer et al. 1985). Roads alone do not provide any of the habitat requirements for deer, although during early spring the the road shoulders and median strips become highly attractive to deer and provide valuable edge. An increase in roads may also indicate a higher

Table 3. Results of the Pearson correlation coefficient matrix; significant relationships.

Variables	Deer damage r	Deer damage p	Deer population r	Deer population p
Deer population	-0.79	0.11	1.00	0.00
Roads	0.87	0.05	-0.95	0.01
Woods	-0.84	0.07	0.91	0.03
Cultivated land	0.35	0.56	-0.82	0.09
Non-cultivated land	0.76	0.14	0.40	0.50
Water	0.67	0.22	-0.11	0.85

level of human land use (increase in non-inventory area), resulting in a decrease in suitable habitat for deer. This may explain the decrease in deer population with an increase in roads.

The negative correlation between deer damage and deer population indicies ($r=-0.79$, $p=0.11$) is not statistically significant; however the correlation seems to suggest that the amount of damage to be expected would increase when the deer population is low. Because young apple trees are prefered food of deer, it would be unlikely that the degree of damage would be dependent on the size of the population. Any deer present, regardless of habitat, would be attracted to new apple plantings and probably cause damage. It is impossible to determine the biological reason for these findings given the sampling restrictions of this study.

Other habitat parameters correlated with deer population include the quantities of woods ($r= 0.91$, $p=0.03$) and cultivated land ($r=-0.82$, $p=0.09$). In Ohio, deer reportedly utilize mixed oak and successional hardwood areas most frequently, although use was found to be seasonal (Heet 1977: 63). In my study, sample areas contained woodlands that were predominantly oak-hickory or bottomland hardwoods. However, many of these woodlots had been or were in the process of being thinned or clear cut. Since deer prefer to browse in open areas (McAninch and Harder 1977), the high correlation between deer population indicies and woods may be mostly due to the high amount of disturbance in wooded areas on the study sites and the emergence of successional hardwoods. To further support this hypothesis, several deer were observed browsing in a patch of woods that had been cleared seven years prior to the sighting (pers. comm. with landowner). This patch was located within 0.75 km of the orchard that had sustained the most severe damage (Madison County). The amount of cultivatied land was negatively correlated with deer population, as expected. Cultivated fields provide limited cover and food sources, consequently they are of limited use as deer habitat. This relationship was statistically weak in this study.

The stepwise regression model (Table 4) suggests that the amount of roads and water would predict 99.9% of the variation in deer damage. Again the road variable was the most significant predictor, explaining 74.9% of the variation. The amount of water, although not significantly correlated with damage, was the only other variable that, when coupled with the road variable, could predict this level of variation.

Future studies could avoid the sample size problem and expense for each sample several ways. Aerial photos of a much larger scale (1:1000 - 1:10,000), taken by or for the researcher would allow for more interpretation in the lab and reduce the amount of field sampling necessary. Since the detailed information obtained from each sample site was not needed in the final analysis, identification of the major cover types on the photos would be sufficient to characterize the habitat at each site. This method would also eliminate the need for preparation of detailed habitat maps, further decreasing the intensity of the study. The habitat evaluation proceedure (HEP) (Lansia et al. 1982, Bart et al. 1984) could also be used as an alternative to the ODNR cover mapping technique (Gehres et al. 1984). The HEP method would be more specific to deer, although it is considered unreliable by many researchers. Once the characterization of deer damage becomes a standardized technique, more

Table 4. Stepwise regression model for the dependent variable deer damage.

Step	Variable	Order of placement in model	Partial R^2	Model R^2	F	P
1	Roads	1	0.7499	0.7499	8.9929	0.0577
2	Water	2	0.2493	0.9992	596.5616	0.0017
3	Edge	3	0.0008	1.0000	59.4381	0.0821
4	Woods	4	0.0000	1.0000	9999.9999	0.0001

sample areas could be located on which the degree of deer damage is known or could easily be determined.

Only through an increase in sample size and a reduction in sampling intensity would a study be successful in determining the true relationship between deer damage and surrounding habitat. Because Ohio white-tailed deer use a variety of habitat types, the production of a model for the prediction of deer damage based on habitat may be impossible.

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Appendix A. Cover mapping field reference list.

00 Non-inventory

10 Water

20 Wetlands
- 21 Meadow
- 22 Marsh
- 23 Swamp
- 24 Bog

30 Openland
- 31 Cultivated
  - 311 Lawns and gardens
  - 312 Soybeans
  - 313 Corn
  - 315 Winter wheat
  - 316 Alfalfa-clover
  - 317 Vegetables
  - 318 Mixed forage
  - 319 Oats
- 32 Non-cultivated
  - 321 Annuals
  - 322 Grass
  - 323 Grass-forbes
  - 324 Forbes

40 Brushlands, old fields, fencerows
- 41 Shrubs-small trees
  - 411 Hawthorn-wild crab
  - 412 Sassafras-sumac
  - 413 Blackberry-rasberry
  - 414 Shrubby dogwoods
  - 415 Multiflora rose
  - 416 Alder
  - 417 Buttonbush
  - 418 Osage orange
- 42 Shrubs-small trees and s.hardwoods
  - 421 Hawthorn-wild crab and s. hwd.
  - 422 Sassafras-sumac and s. hwd.
  - 423 Blackberry-rasberry and s. hwd.
  - 424 Shrubby dogwoods and s. hwd.
- 43 Successional hardwoods
- 44 Conifers
  - 441 Shortleaf-Virginia pine
    - 4411 Shortleaf pine
    - 4412 Virginia pine
  - 442 Eastern red cedar
    - 4421 E. red cedar and s. hdw.
    - 4422 E. red cedar
  - 443 Red-white pine
    - 4431 Red pine
    - 4432 White pine
    - 4433 Scotch pine
    - 4434 Austrian pine
- 45 Orchards
  - 451 Apple
  - 452 Pine
  - 453 Plum

50 Woodland
- 51 Successional hardwoods
- 52 Upland hardwoods
  - 521 Oak-hickory
  - 522 Beech-sugar maple
  - 523 Elm-ash-maple
  - 524 Black locust
  - 525 Yellow poplar
  - 526 Aspen
- 53 Bottomland hardwoods
  - 531 Sycamore-cottonwood-silver maple-elm-willow
  - 532 Pin oak-maple
- 54 Oak-pine
  - 541 Oak-shortleaf pine
  - 542 Oak-Virginia pine
- 54/55 Mixed woodlands
- 55 Pine-oak
  - 551 Shortleaf pine-oak
  - 552 Virginia pine-oak
- 56 Conifers
  - 561 Shortleaf-Virginia pine
    - 5611 Shortleaf pine
    - 5612 Virginia pine
  - 562 Red-white pine
    - 5621 Red pine
    - 5622 White pine
    - 5623 Scotch pine
    - 5624 Austrian pine
  - 563 Hemlock